20

PROBE MEASUREMENTS IN D. C. & H. F. GAS DISCHARGES

G. L. GUPTA AND D. R. GUPTA

DEPARTMENT OF PHYSICS, UNIVERSITY OF JODHPUR, JODHPUR, INDIA.

(*Received January* 11, 1968; *Resubmitted August* 9, 1968)

In a paper published by Kojima, Takayama and Shimauchi (1953) a method for the measurement of electron temperature in high frequency discharge by the use of double probes has been given. It has been concurrently shown that the obtained results for h.f. plasma are approximately equal to those of direct current discharge.

Theoretically the electron temperature of d.c. plasma was given by Engel and Steenbeck (1934) in the expression :

$$\left(\frac{eV_i}{kT_e}\right)^{-\frac{1}{4}} \exp.\left(\frac{eV_i}{kT_e}\right) = 1.16\times10^{7}C^2p^2R^2 \qquad .. \quad (1)$$

where p is the gas pressure in mm.Hg., R is the radius of the discharge tube in cm., V_i is the ionization potential of the gas and C is a constant depending upon the kind of gas. For Argon V_i and C are 15.7 volts and 5.3×10^{-2} (mm.Hg.cm)$^{-2}$ respectively. In h.f. measurements, R has to be replaced by the equivalent radius of the tube, R_e defined by :

$$R_e = 2.405\lambda \qquad (2)$$

where λ is the diffusion length introduced by Brown and MacDonald (1951) with the equation :

$$\left(\frac{1}{\lambda}\right)^2 = \left(\frac{\pi}{L}\right)^2 + \left(\frac{2.405}{R}\right)^2 \qquad (3)$$

L and R being the length and the radius of the cylindrical tube.

Experiments have been conducted in the d.c. plasma of Argon gas (branded as spectrally pure) in the pressure range of 62×10^{-4} to 77×10^{-2}mm.Hg. using a tungsten wire probe of length 3.45 cm. and diameter 0.22 mm. The diameter of the discharge tube used was 6.0 cm. The design of the probe conformed to that recommended by Gupta (1956), its location being so as to create a minimum disturbance in the ionised gas.

Using the graphical data provided by Kojima *et al* (1953) for the h.f. plasma, the electron temperatures corresponding to the pressures mentioned above, for a d.c. plasma, have been tabulated below :

1	2	3	4	5	6
Pressure (mm.Hg.)	pR_e (mm.Hg.cm.)	T_e (Kojima curve for h.f.plasma) °K	T_e (Experimentally for d.c. plasma) °K	T_e (Theoretically from eqn. 1 for d.c. plasma) °K	mean free path cm.
0.0062	0.018	—	12,800	60,000	6.83
0.0096	0.028	—	85,000	48,000	4.44
0.013	0.038	35,000	31,000	37,000	3.28
0.77	2.25	13,700	14,100	13,500	0.055

A comparison of the values in the columns 3 and 4 of the table shows that our experimental results of electron temperatures from the d.c. plasma tally with those obtained by Kojima *et al* (1953) for a h.f. discharge and provide a good support to their conclusion. The close agreement between the values in columns 4 and 5 in the case of a d.c. plasma provide a further measure of support to the above and shows excellent agreement between the experimental and theoretical results, the variance coming only when the mean free path for the electrons becomes comparable to the tube diameter as shown in the column 6 of the table.

The validity of the probe as a convenient tool in the measurement of a gas discharge parameters has been brought out clearly by the results given in the columns 3,4 and 5 which are within the limits of experimental error. The reliability of results obtained from probes is dependent on the gas pressure and the probe dimensions. That there is no agreement between the values of T_e at 0.0062 mm and 0.0096 mm. pressure in the column 4 and 5 support our argument. They are not expected to hold good (Engel and Steenbeck 1934; Gupta 1956). Further it has not been possible with any degree of approximation to extrapolate the values of T_e for high frequency plasma (col. 3) from the T_e—pR_e curve provided by Kojima *et al* (1953).

REFERENCES

Kojima, Shoji, Takayama, Kazua, Shimauchi, Akira, 1953. *Phys. Soc. Japan*, **8**, 55.
Engel, A. V. and Steenbeck, M. 1934. "*Electrische Gasentladungen*" Berlin, Pt. II.
Brown, S. C., and MacDonald, A. D., 1951. *Phys. Rev.*, **76**, 1629.
Gupta, G. L., 1956. *Raj. Univ. Phys. Sc. Studies (India)*, I & II, 34 and 51.